Total Carbon Analysis from Intact Soil Cores with Laser-Induced Breakdown Spectroscopy

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Measurements for Carbon Inventories

Are there new methods for accurate, rapid carbon measurements?

- **Carbon concentrations with accuracy and precision equal to or better than current methods**
- **Data in minutes rather than days, weeks, or months**
- **Measurements while in the field**
- **Different scales: plots to landscapes**
- **Adequate sampling at reasonable cost**

Laser-Induced Breakdown Spectroscopy (LIBS)

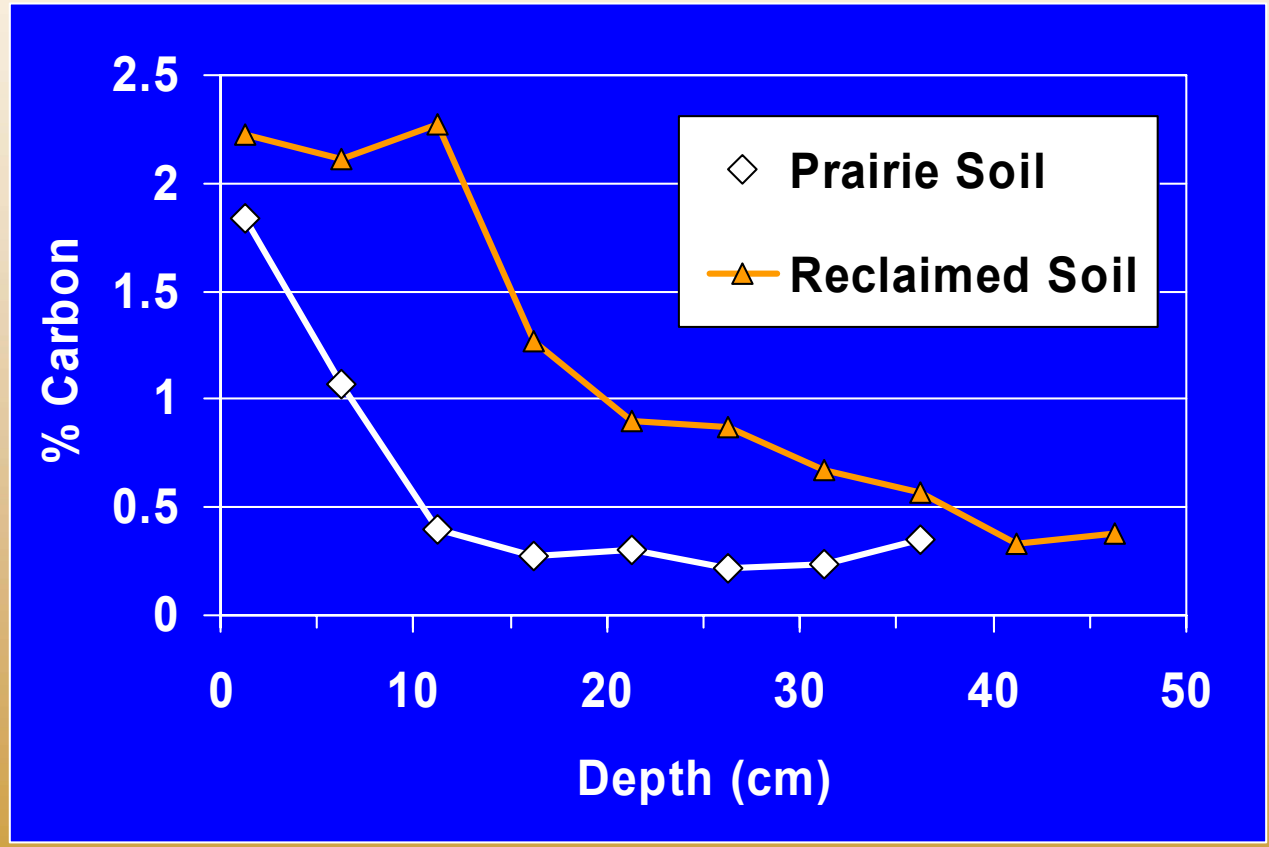
- **Field portable**
- **Works with soil cores and discrete samples**
- **Rapid total carbon analysis (minutes)**
- **Inexpensive to operate**

Carbon Distribution at Different Scales

- **Sample plots or landscapes?**
- **How many samples are representative?**
- **How much sampling is affordable?**

Spatial Variation of Carbon in Soil

- Prairie soil core, 40 cm depth
- Reclaimed soil core 48 cm depth (similar soil type)
- Concentration data at 5 cm intervals
- Dry combustion analysis



Soil Heterogeneity

- Scale model of a soil at 1000X mag.
- Carbon distributed discretely, but throughout the matrix
- Homogeneous?

One Solution: LIBS Analysis of Intact Core

- **Analysis of soil core 1mm at a time**
- **C concentration data at 1mm to 1 cm resolution**
- **Entire core analyzed in ~30 minutes**

LIBS: Schematic Overview

- **Nd:YAG Laser at 1086 nm**
- **Pulsed at 10Hz**
- **1mm spot size**

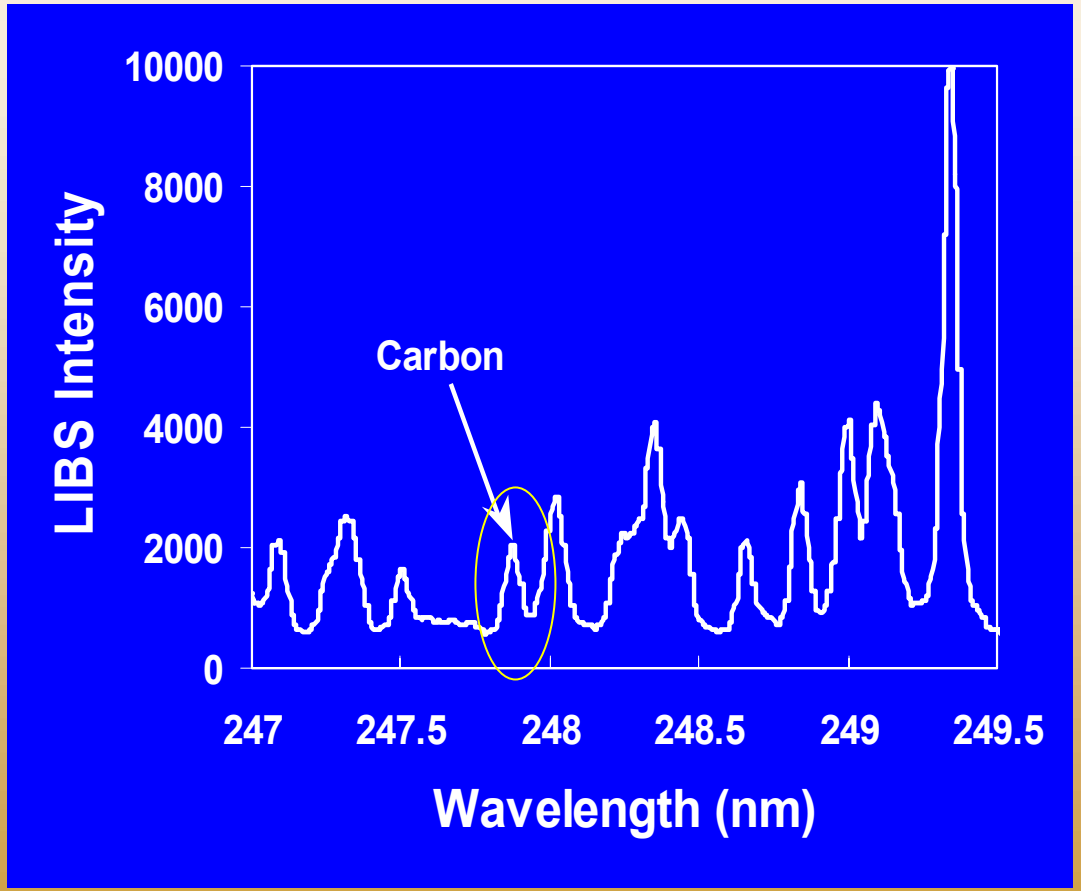
1mm Laser Spark on Soil

Eschelle Spectrograph & Computer

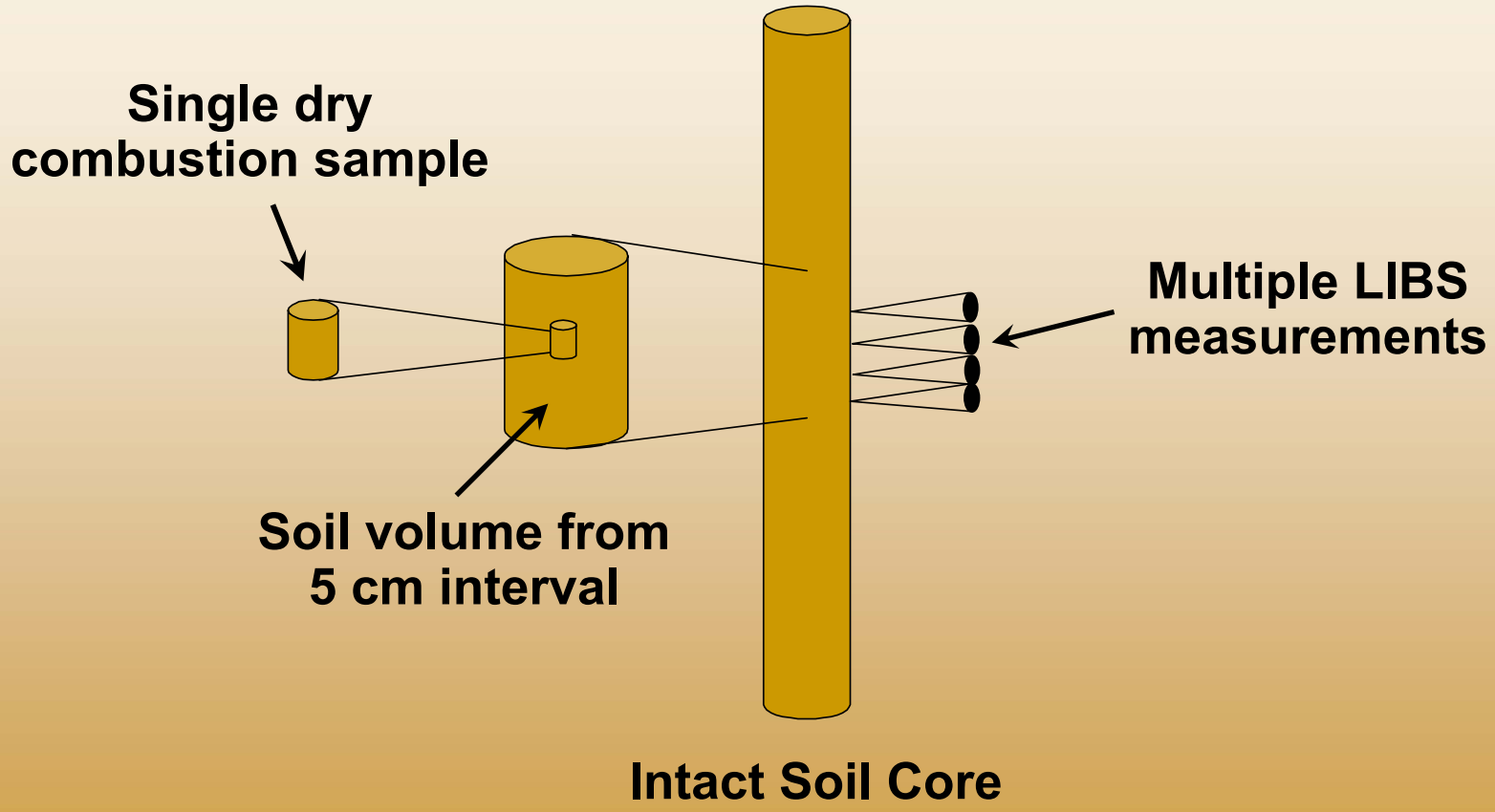
Spectrum from Plasma

LIBS Spectrum (Partial)

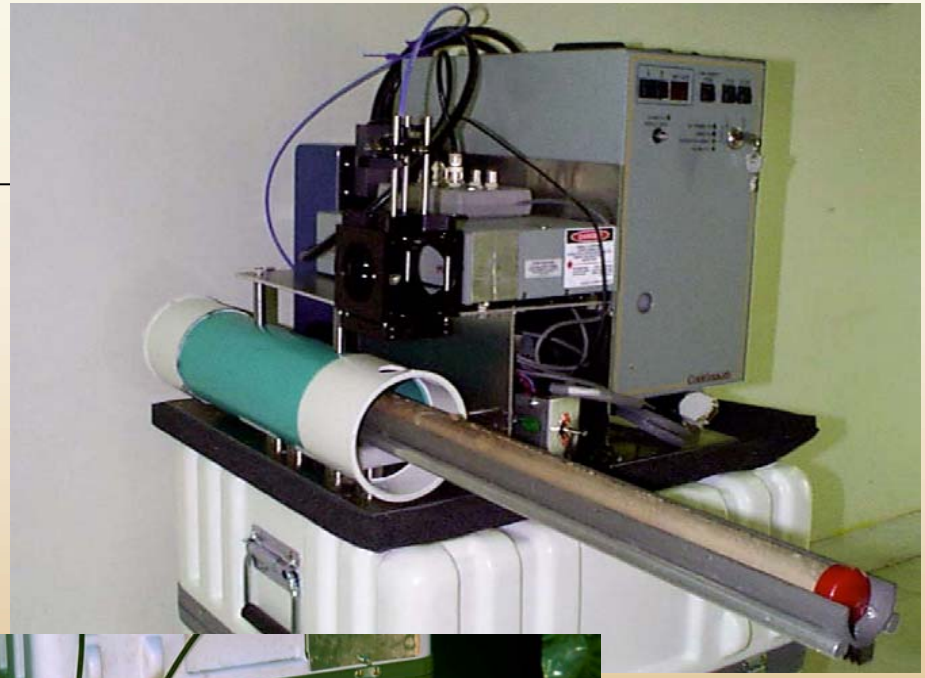
- **Carbon line: 247.89 nm**
- **Increased intensity = increased carbon**
- **Can detect other elements: H to U**



Dry Combustion vs. LIBS

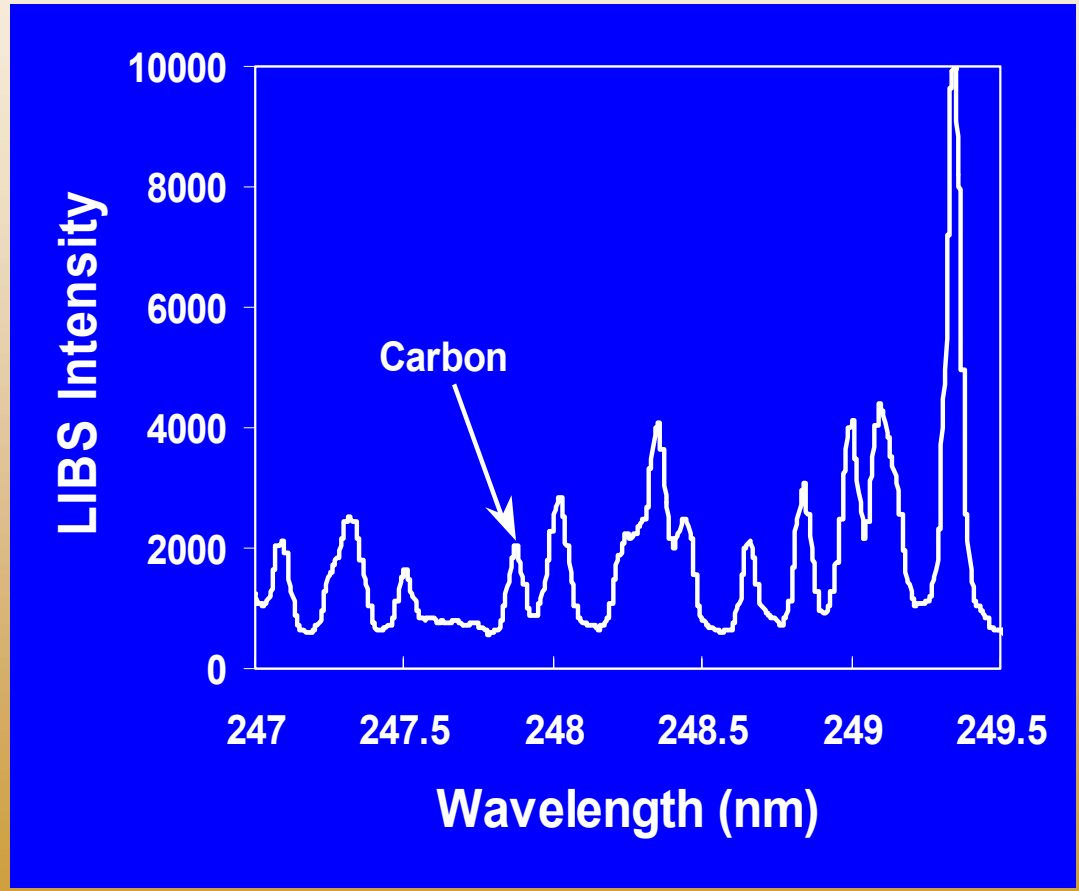


An Intact Soil Core

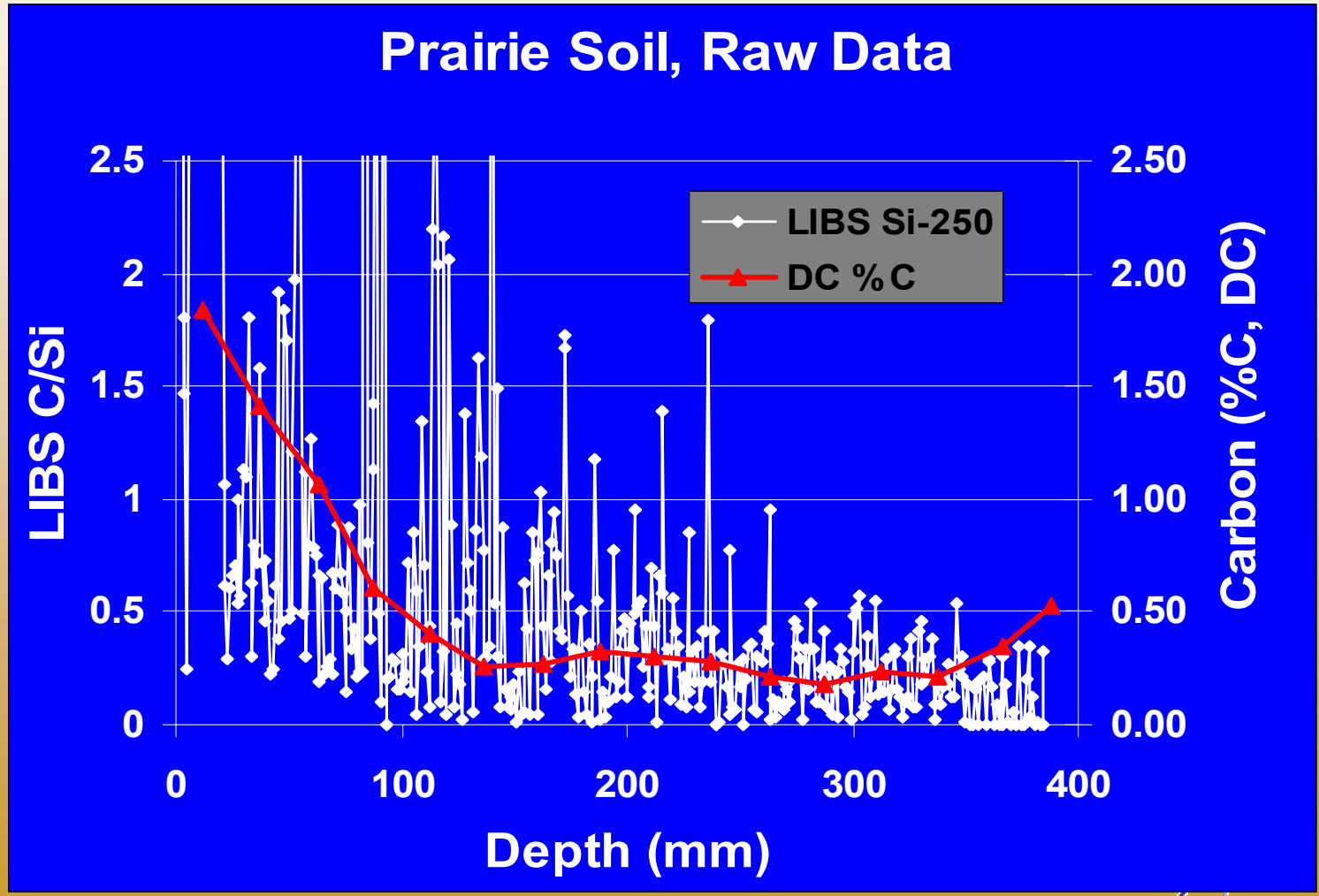


LIBS Core Measurements

- **C/Si Ratio for each 1mm or 1 cm step**
- **Plot with depth in profile**
- **Combine LIBS data to specific intervals**

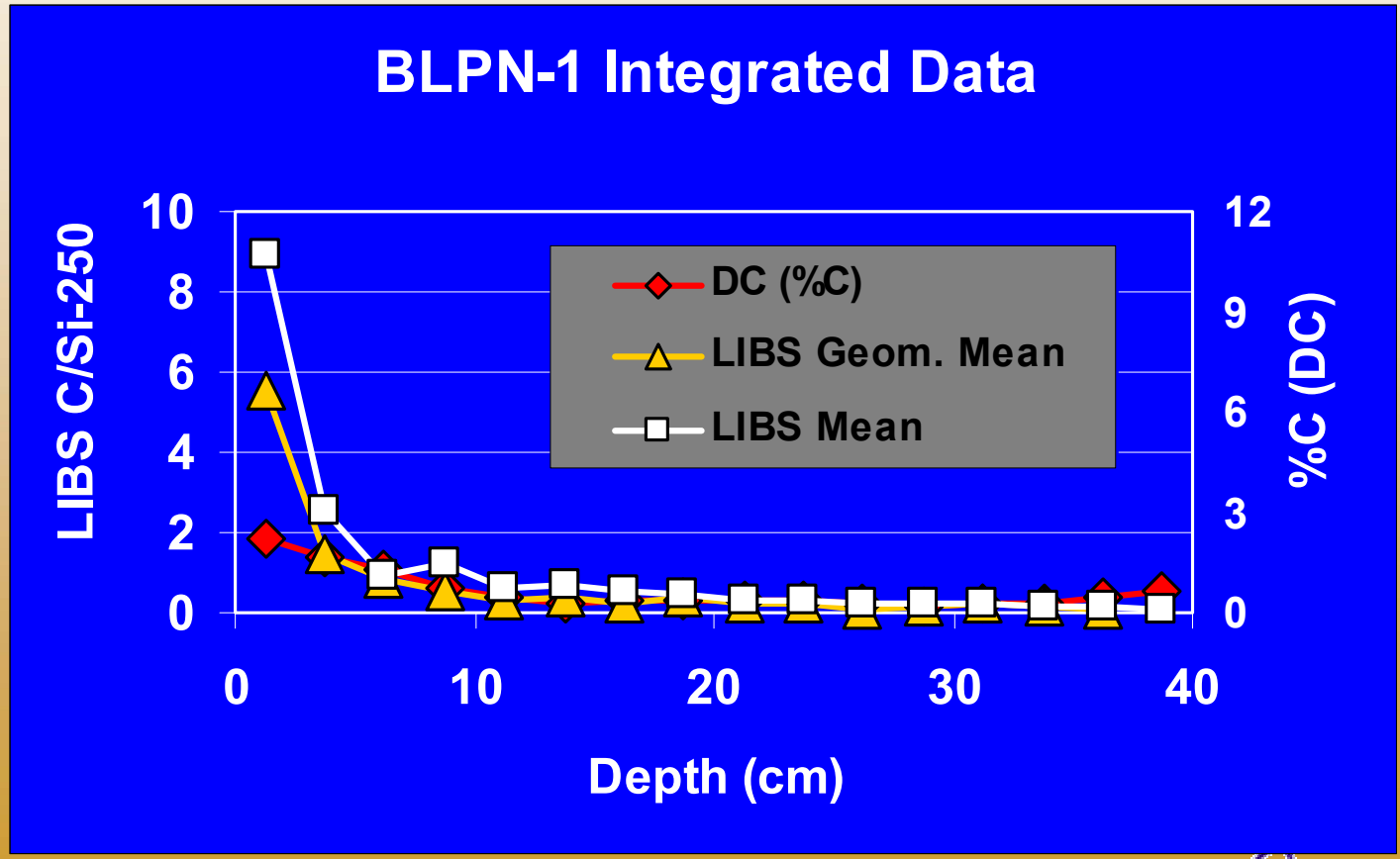


LIBS Data from Intact Soil Core



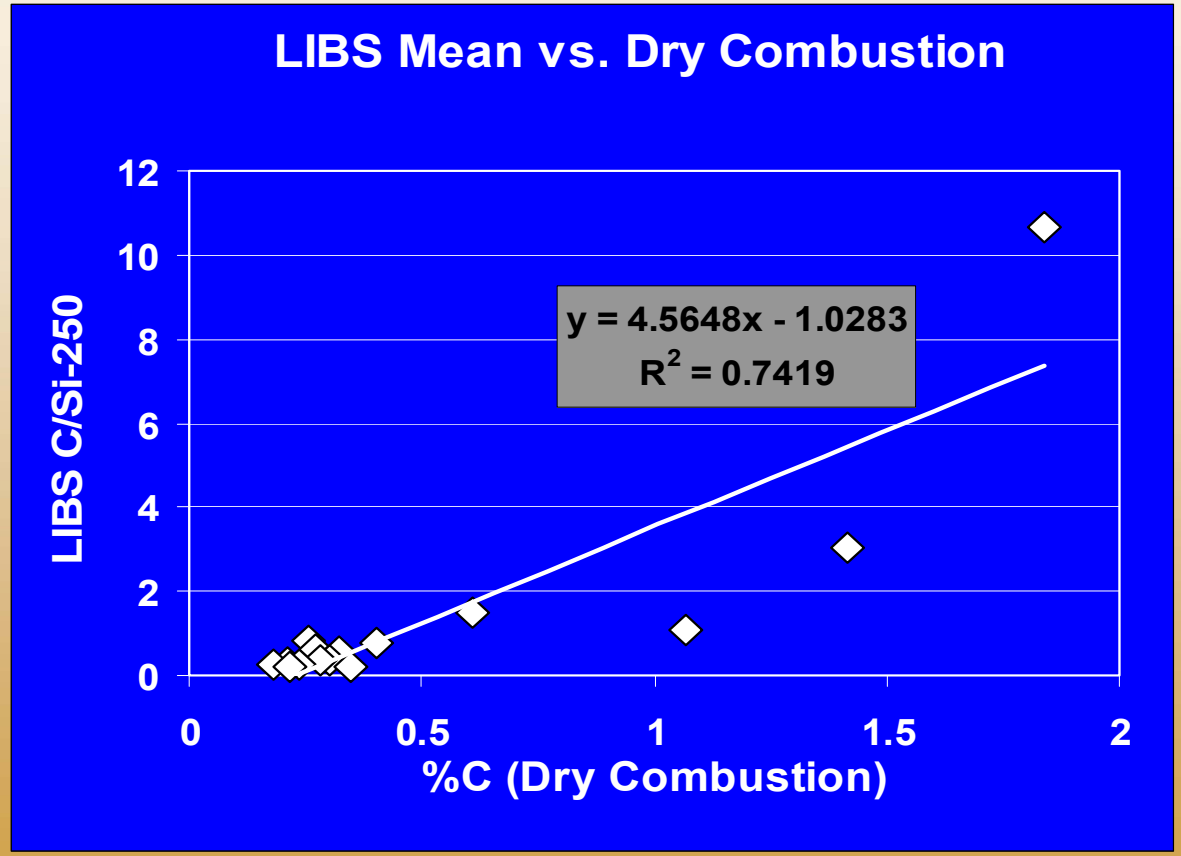
LIBS Data from Intact Soil Core

Each LIBS *point* is 12 to 20 *measurements*

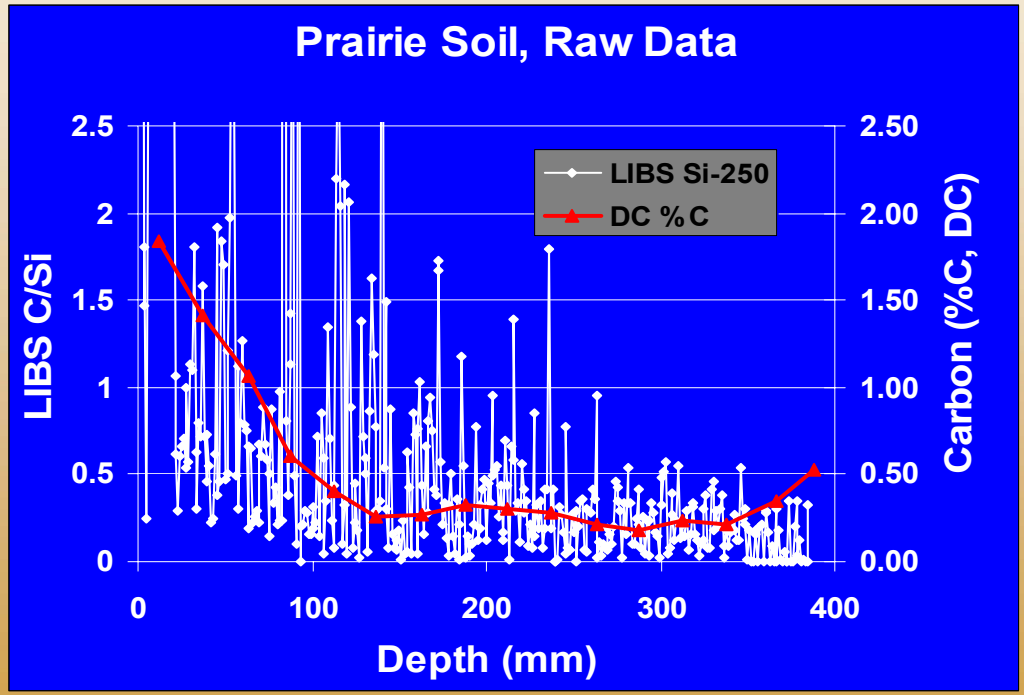


LIBS-Dry Combustion Correlation

- **LIBS mean intensity correlates with C/Si ratio**
- **Deviation at high C: change of soil matrix (Si, bulk density)**



LIBS Benefits



- About 40 minutes to collect LIBS data; 10 minutes to collect and prepare core; all in-field
- About 1 week to collect, prepare and analyze DC samples and data in lab
- Uses *spatial variation* of carbon and includes *soil heterogeneity*

New Methods of Carbon Measurements?

Does LIBS method provide accurate, rapid carbon measurements?

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